Development of a Thermodynamic Performance Tool and Application to a Turbofan by Maxime Jacquin

Context and Motivations

- Altran internal research project in Fluid and Energetics in Propulsive System to extend turbomachinery design capacities
- Multiphysic low level modelling technics to limit utilization of costly detailed model
- Computer program: Thermodynamic Performance Tool to perform 0-D modelling analysis of gas turbine equipment and macroscopic aircraft performance calculations

Objectives

1. Implementation of the aircraft engine components
   - inlet, nozzle
   - compressor, fan, turbine
   - combustion chamber
2. Implementation of operating characteristics
   - compressor maps for core compressor and fan
   - loss model using CFD for inlet and nozzle
3. Application to a turbofan
   - cruise phase
   - mission

Operating characteristics

Program main functions:
1. Read the text files containing the data \( (N, \dot{m}, \pi, \eta) \) and store it
2. Transfer the results in a matrix adapted to the interpolation function
3. Identify for a given \( N \) the range of \( \dot{m} \) allowed (between surge and shock lines)
4. Test if the mass flow rate guess value defined by the user is included in the valid range for a given \( N \). Raise error if it is not the case
5. Interpolate linearly \( \pi \) and \( \eta \) for a given couple \( (\dot{m}, N) \)

Modern core compressor performance map
(Nicholas Cumpsty and Andrew Heyes. Jet propulsion. Cambridge University Press, 2015.)

Graphical User Interface

Architecture of the two spool turbofan tested

Major achievements

• Aero-thermodynamic models implemented for 6 components
• Ergonomic improvement of the GUI
• Integration of performance maps for compressor and fan
• The program has demonstrated its capacity to converge to a basic solution:
  - Two-spool turbofan in cruise phase at FL350 Mach 0.85

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